ONR Mine Burial Prediction Science Program *In Situ* Sediment Pore Water Pressure Studies (Liquefaction Potential) and Mine Burial Prediction Science Program Coordination and Initiation of Technical Program

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LONG-TERM GOALS

The ultimate goals are to substantially improve, quantitatively, the U.S. Navy's mine burial predictive capabilities and to provide a strong technical basis for an ONR science program in Mine Burial Prediction in basic and applied research (Bennett et al., 1999, Bennett and Wilkens, 2000, Bennett, 2000). The goals include technical direction for developing and improving Naval Fleet Aids. The U.S. Navy's capabilities must be substantially improved to meet operational and fleet requirements in mine burial prediction for shallow-water coastal environments. Specific SEAPROBE goals are to 1) implement, coordinate, and assist in the development of the Mine Burial Prediction Science Program under the directives and management of ONR scientific officers and 2) participate in the ONR Field Program and perform in situ pore water pressure studies. This effort includes an intensive instrumentation evaluation, study, and reconditioning of the Multi-Piezometer Array System (MPAS). Interaction and coordination with participants in NATO Mine Burial Subgroup has been an important aspect of the long-term goals of the mine burial studies (NATO SG/31, 1999).

OBJECTIVES

The research objectives are to 1) test and evaluate existing models of liquefaction by full scale field experimentation using the Multi-Piezometer Array System (MPAS); 2) evaluate instrumentation performance by limited laboratory and wave-tank testing; and 3) conduct theoretical, analytical, and numerical analysis and computer simulations of existing liquefaction models in cooperation with program participants. Another important aspect of the effort is to coordinate the research program in support of the Office of Naval Research. The Office of Naval Research requires that the technical aspects of the Mine Burial Prediction Science Program (MBP-SP) be coordinated among participating principal investigators and institutions to provide linkages, cooperation, and sharing of research data and results with the initial development of an ONR Mine Burial Web Site. Thus, an objective of SEAPROBE was to convene several technical workshop and develop a preliminary web site for information and data sharing that will later be transferred to a permanent web site at a university participating in the MBP-SP.

APPROACH

The technical effort involves two areas 1) experimental research and 2) science program coordination, however, many tasks are required within each major area.

1) EXPERIMENTAL RESEARCH

A. Reconditioning and Modification of MPAS (FY-2001)

Evaluation, repairs, and testing were necessary to upgrade the MPAS for field deployments in the MBP-SP. Improvements and changes in the CPU and the piezometers were required.

B. MPAS Testing and Evaluation and Wave Tank Testing

SEAPROBE conducted simple dynamic tests of piezometer probes under controlled conditions with and without mechanical design changes to determine instrument behavior, integrity of signal response, and potential spurious signal response. Tests were conducted in air and in saturated sediment and piezometer probe design modifications were made to test probes under dynamic conditions. Data were analyzed to determine probe response to motion and to assess optimum electronic system design modifications for system reliability. Wave tank testing of the piezometer probes will be performed at the University of Illinois in cooperation with Dr. Marcelo Garcia. Data will be analyzed to determine MPAS system reliability and potential for field applications.

C. Test and Evaluation of Liquefaction Models

The thrust of this research effort is to 1) test and evaluate existing models of liquefaction by full scale field experimentation including instrumentation performance by limited laboratory wave-tank testing and 2) conduct, as required, theoretical, analytical, and numerical analysis and computer simulations of existing liquefaction models in cooperation with program participants. Modeling will be in cooperation with Dr. Chiang C. Mei, MIT, Dr. Horst Brandes, University of Hawaii, Dr. Marcelo Garcia, University of Illinois, Dr. Wayne Dunlap, TAMU, and possibly international participants.

2) SCIENCE PROGRAM COORDINATION AND WEB SITE

A. Program Coordination

SEAPROBE, Inc. (Richard H. Bennett, P.I.) will coordinate the science program in Mine Burial Prediction both offshore (field) and shorebased activities under the program management of the Office of Naval Research (ONR). The technical multidisciplinary program will encompass the disciplines and expertise of marine geology and geotechnique, climatology and meteorology, shallow water physical oceanography, bathymetry and morphology, sedimentology, high-resolution geophysical profiling, modeling and statistics, mine physical characteristics and behavior in coastal environments, science and engineering applications and Fleet Aids. The program includes international participants. The ONR science and engineering program in mine burial prediction encompasses a series of workshops, meetings, and technical assessments and reports.

B. Web Site

The development and maintenance of the ONR Mine Burial Prediction Science Program web site is an important aspect of the program. The web site includes reports from workshop, meeting and ONR announcements, technical data, program participants, etc., and will be a repository for field databases and information exchange as required.

WORK COMPLETED

The technical work and activities completed in FY-2001 in the areas of 1) Experimental Research and 2) Program Coordination and that are presently ongoing in support of the ONR Mine Burial Prediction Program are summarized below.

1) Convened three ONR MBP-SP workshops. SEAPROBE, Inc. A) developed the purpose statements for the workshop; B) develop the technical outline, agenda, strategies, plans and goals for the workshops; C) conducted the appropriate communications with specialist and workshop participants and teams leaders; D) arrange travel for all ONR sponsored guests; and E) arranged as required the meeting locations and coordinated lodging and logistics for the workshops. SEAPROBE also assisted in planning and coordination of the NAVO workshop (February 7, 2001) with Dr. Peter Fleischer at Stennis Space Center to review NAVO database holdings for specific offshore areas for MBP-SP site selection. We participated in an ONR sponsored meeting at the University of New Hampshire with Dr. Roy Wilkens, ONR, Dr. Larry Mayer, and others, to discuss the development of a permanent web site for the MBP-SP. Technical plans were outlined and schedules were developed.

2) Completed comprehensive technical workshop reports and entered these reports on the ONR website for the following workshops:

- Impact Burial Workshop, November 14-15, 2000, Crystal City, VA
- Review of NAVOCEANO Holdings: Acoustic Imagery and Sediment Data off Corpus Christi, TX, February 7, 2001, Stennis Space Center, MS
- Coastal Processes Driving Mine Burial Workshop, January 30 – February 1, 2001, St. Petersburg, FL
- ONR Mine Burial Prediction Science Program, Coastal Processes Group Workshop, April 4, 2001, Arlington, VA

3) Completed the following technical report:

Bennett, Richard H., 2001. Implementation of Initial Technical Activities for the Mine Burial Prediction (MBP) Team: Science and Engineering Requirements. SEAPROBE, Inc. Technical Report No. SI-0001-01, 21p.

4) Continued development and placement of materials on the web site for the ONR Mine Burial Prediction Science Program. The web site includes references, planning documents, program plans, relevant reports, scheduling, meeting plans, MBP Workshop report, findings, and recommendations and ONR announcements.

5) Finalized selection of the offshore sites for the MBP-SP and continued literature searches for the appropriate environmental data required by the program participants. This includes web site accessible data and information.

6) Completed the major portion of the technical evaluation of MPAS and repairs (electronic and mechanical components). Wave tank tests are planned for FY-2002.

7) Set up laboratory tank for testing dynamic response of probes and measured important sediment (sand) properties. Completed initial laboratory testing of MPAS in laboratory tank to assess dynamic performance of the piezometer probe system. Laboratory tank tests at large horizontal forces (up to 50lbs or 220 N) showed no significant pore pressure response.

8) Repaired 9 piezometer probes and performed calibrations on six; other calibrations on additional probes to be completed in FY-2002. Replaced the CPU in the bottom-side computer system and replaced numerous electronic components in damaged piezometer probes.

9) The mechanical design of one probe was modified (electronic components decoupled from the probe shaft) for testing the dynamic effects on pore pressure signals.

10) Completed general maintenance and inspection of the MPAS including mechanical and electronic components.

RESULTS

1) SCIENCE PROGRAM COORDINATION AND WEB SITE

The workshops are providing the necessary background to provide the Navy with direction for developing a technical program that is encompassing the disciplines of marine geology and geotechnique, climatology and meteorology, bathymetry and morphology, modeling and statistics, and mine physical characteristics and behavior in coastal environments. This includes the science and engineering applications for the Fleet and Operational Navy personnel. Thus, an ONR science and engineering program plan is now being developed with a two-prong effort; one in basic science and one in applied science. The following narrative reviews the essential requirements established for the Mine Burial Program.

A close interaction among the scientific and engineering community and Navy operational personnel is now ongoing in the MBP Science Program. This is being accomplished by the interaction of Group Coordinators and a Steering Committee who interacts with ONR, NAVOCEANO and COMINEWARCOM technical staff. The Steering Committee and Group Coordinators provide an important interface and technical link between the operational navy and the science and engineering community involved in the Mine Burial Prediction Science Program. ONR has oversight of the program.

Workshop results have determined that the MBP-SP will require expertise in bedform migration, scour and sedimentation, impact burial, geotechnical properties and processes, coastal processes, climatology, numerical and analytical modeling, statistics and probability modeling, instrumentation, geological mapping, and large-scale laboratory studies. Upgrading and development of new mine burial models requires comprehensive knowledge of seafloor properties and processes as well as

mechanisms that drive mine burial in coastal environments. Detailed data on the statistical distribution of sedimentological/geotechnical properties are required. Well-planned field and laboratory experimentation addressing environmental processes, seafloor sediment variability, and coupled processes are of paramount importance. Input from the Operational Navy will provide a strong underpinning for the success of the program.

Field schedules are planned for the Mine Impact Burial Studies off Corpus Christi. Detailed plans are ongoing for the scheduling of fieldwork off Martha's Vineyard and off Tampa, FL to conduct Coastal Processes Studies on subsequent mine burial in granular sediments.

2) EXPERIMENTAL RESEARCH

The Multi-Piezometer Array System was evaluated and numerous parts and subsystems repaired or replaced. Presently, 75% of the piezometer probes (9 of 12) have been made functional and the CPU has been upgraded substantially. When the system was acquired by SEAPROBE the electronic components and many mechanical components were severely damaged and some totally nonfunctional. A large part of the system is now ready for wave tank tests and evaluation and we expect the MPAS to be field worthy and ready for deployment in the scheduled program exercises. Considerable progress has been made, however, additional work is required in FY-2002 to complete system maintenance, upgrading, and repairs.

Preliminary dynamic laboratory testing of MPAS has demonstrated excellent system response and planned wave tank tests will compliment the piezometer probe response and electronics evaluation prior to field deployment.

IMPACT/APPLICATIONS

A substantially improved quantitative capability for the U.S. Navy's Fleet and Operational Forces is anticipated. The mine burial predictive capabilities will provide a strong technical basis for enhancing the U.S. Navy's capabilities and fleet requirements in mine burial prediction for coastal environments not only for domestic applications but also for international scenarios. The goals include the improvement of Naval Fleet Aids.

TRANSITIONS

The ONR Mine Burial Prediction Program will integrate field, laboratory, and theoretical modeling with statistical, scientific and engineering contributions, to advance the state-of-the-art in mine burial prediction and support transition of scientific results to applied problems for the Operational Navy.

RELATED PROJECTS

Numerous projects addressing sediment transport processes, marine geology, and oceanography are ongoing that focus on questions fundamental to mine burial. In the USA, the ONR Programs in Geology and Geophysics and Coastal Dynamics support and coordinate basic and applied research in the field of shallow-water sediment transport processes, and geology and geophysics of the continental shelves. Other organizations are collaborating in the ONR programs including coastal geologists from the U.S. Geological Survey, coastal engineers from the U.S. Army Corps of Engineers, and university scientists involved in National Science Foundation research grants. Staff scientists at the Naval

Coastal System Station (NCSS), Naval Research Laboratory (Stennis Space Center, MS), and Scripps are conducting mine burial tests. The mine burial work at NAVOCEANO has included extensive effort in the development of surficial geology maps of selected coastal areas of the world. These maps depict the sediment and other geological material types from the shoreline to water depths of 200 meters. Continuation of U.S. participation in the NATO Mine Burial Studies are presently in discussion with European allies.

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PATENTS

None